



Fermi National Accelerator Laboratory

FERMILAB-Pub-75/89-EXP
7100.305

UR-560 COO-3065-135

NU-HEP-2

(Submitted to Phys. Rev. Lett.
Comments)

NEUTRON-NUCLEAR TOTAL CROSS SECTIONS BETWEEN 30 AND 300 GeV/c

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December 1975

Neutron-Nuclear Total Cross Sections Between
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Neutron total cross sections on Carbon, Aluminum, Copper, and Lead have been measured at Fermilab for momenta between 30 and 300 GeV/c. Comparison is made between these measurements and previous total cross section determinations.

§Research supported by the United States Energy Research and Development Administration.

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Precision determinations of neutron total cross sections on nuclear targets in the 30 GeV/c to 300 GeV/c range have recently been reported. ⁽¹⁾ We have performed a similar set of measurements in the M-3 neutral beam of the Fermi National Accelerator Laboratory using the standard good geometry transmission technique. A novel feature of the experiment was the method employed for neutron detection. A 0.25 inch thick Pb neutron "converter" was placed in front of a high resolution forward V-spectrometer. The spectrometer was triggered on the coherent dissociation of the neutron into a $p\pi^-$ system (V), produced in the reaction $n + Pb \rightarrow (p\pi^-) + Pb$, and provided us with excellent positional and energy-measuring capability for transmitted neutrons. ⁽²⁾ We measured the rate of V production with and without a nuclear transmission target located ~200 meters upstream of the spectrometer; the ratio of these yields, normalized by an independent beam monitor, was used to determine total cross section for neutrons on specific targets. ⁽³⁾

Our spectrometer enabled us to measure the momentum of each detected V to $\pm 1\%$ accuracy; we therefore obtained directly the momentum dependence of the total cross section for each target element. Furthermore, the excellent spatial resolution ($\sim \pm 0.03$ cm) of our neutron detector was a valuable asset in making corrections for those neutrons which undergo small angle scattering in the transmission target but still strike the Pb converter and yield detectable V's. We found that the absolute corrections for such small-angle scatters never exceeded one half the statistical error on the measured cross sections. We have investigated other possible sources of systematic error and believe that our total cross section determinations constitute measurements which are effectively model independent, and limited only by statistical uncertainty. ⁽⁴⁾

The results of our measurements are presented in Fig. 1 and tabulated in Table I. The data points on the figure are our measured values; the cross-hatched region represents previously published results in this energy regime. ⁽¹⁾ (The limits of the cross-hatched region correspond to ± 1 standard deviation variations from the measured values.) The solid curve summarizes results at lower energies. The two high energy measurements appear to be in good agreement for Pb, but display systematic disagreement as the atomic number decreases. (We can provide no obvious explanation for this small but significant discrepancy; if the method of correcting for small angle scattering were at fault, the disagreement would be expected to be most pronounced for large A.) One effect of the disagreement between the two experiments is that if one chooses to parameterize the A dependence of the neutron-nuclear total cross section $\sigma_T(A)$ in the form $\sigma_0 A^v$, then our v values are systematically larger than those reported in ref. 1. ⁽⁵⁾ Another, perhaps more interesting, consequence is that while the qualitative agreement between the data and Glauber theory (including inelastic screening) remains, ⁽¹⁾ the quantitative level of this agreement is worsened.

We thank J. P. DeBrion, D. Chaney, R. Lipton, P. Mühlemann and R. Scott for assistance in the running of the experiment. We also acknowledge the excellent support of P. Koehler and the staff at the Meson Detector Laboratory during the execution of the experiment.

Table I
Neutron-Nuclear Cross Sections

Momentum Range (GeV/c)	Cross Section (mb)			
	Carbon	Aluminum	Copper	Lead
30 - 80	336 \pm 9	645 \pm 23	1268 \pm 36	3087 \pm 88
80 - 130	319 \pm 6	603 \pm 14	1167 \pm 22	2830 \pm 53
130 - 170	323 \pm 5	623 \pm 12	1206 \pm 19	3037 \pm 47
170 - 200	309 \pm 5	588 \pm 12	1181 \pm 19	2963 \pm 48
200 - 220	323 \pm 6	607 \pm 14	1204 \pm 23	2953 \pm 56
220 - 240	312 \pm 6	611 \pm 15	1238 \pm 23	2944 \pm 57
240 - 260	326 \pm 7	620 \pm 16	1272 \pm 25	3063 \pm 62
260 - 300	320 \pm 7	631 \pm 17	1200 \pm 27	2982 \pm 67

References

1. L. W. Jones et al, Phys. Rev. Letters 33, 1440 (1974); P. V. R. Murthy et al., Nucl. Phys. B92, 269 (1975). These papers also provide an excellent summary of work performed at lower energies.
2. Detailed descriptions of our spectrometer, and of the explicit triggering scheme employed, have been presented elsewhere. See, for example, J. Biel et al., Phys. Rev. Letters (to be published); T. Ferbel in Proc. of the Intl. School of Subnuclear Physics - Erice (1975), A. Zichichi, ed.
3. The neutral beam contained minor components of γ , K_L^0 and \bar{n} . The γ 's were effectively removed using a 2 inch thick Pb filter. Corrections due to K_L^0 and \bar{n} contaminants were negligible because of the nature of the detection scheme. This point will be discussed more fully in a forthcoming publication.
4. A more complete discussion of the experimental details is being prepared for publication. For a preliminary presentation of these measurements, see P. Slattery, Proc. of APS/DPF Meeting at Seattle (1975), H. Lubatti (ed).
5. The average value of v is ~ 0.78 near 30 GeV/c; in excess of 30 GeV/c, v falls below 0.77 for the data of reference (1), and rises to 0.79 for our data. Although small, these differences are statistically significant.

Figure Caption

Neutron-nuclear total cross sections measured in this experiment. The cross-hatched region represents the previously available data in this energy regime (ref. 1); the curve summarizes lower energy results.

